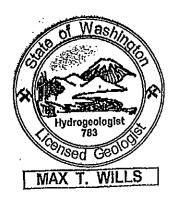


2007 ANNUAL REPORT ON THE PORT LUDLOW AREA GROUNDWATER MONITORING PROGRAM FOR PORT LUDLOW ASSOCIATES, LLC

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Introduction

As a condition of plat approval, Jefferson County required that Port Ludlow Associates, LLC conduct a groundwater-resource monitoring program. To that end, Robinson, Noble, & Saltbush, Inc. was retained to develop, conduct, and supervise such a program. The program was initiated in April 1994 with the contacting of possible participants. The monitoring program concentrates on the North and South Aquifers (described below) and encompasses the area presumed to overlie these acuifers as well as a substantial area surrounding each aquifer. The current groundwater monitoring network is comprised of 18 wells owned and maintained by seven separate participants. In 2007, no new wells were added to or deleted from the monitoring network. In 2005, Olympic Water & Sewer, Inc. (OWSI, formerly Ludlow Water Company) completed two new production wells (Wells 15 and 16) in the South Aquifer. OWSI does not have immediate plans to use Well 15 for production, but is currently in the process of bringing Well 16 on line. Both Wells 15 and 16 were added to the monitoring network during 2005.

The goal of the monitoring program is to assess the long-term condition of the aquifers in the Port Ludlow area. The program focuses on collecting five basic parameters: 1) static water levels, 2) pumping water levels, 3) quantity of pumping, 4) water quality, and 5) Precipitation. Water levels were initially taken twice a month during the summer months, and once a month during the rest of the year. The volume of water pumped from each of the wells in the network is recorded where available. Water quality samples were taken twice in the first year and annually thereafter. Rainfall measurements are being taken at the OWSI office. The following report provides an assessment of the data collected to date.

Modification of Monitoring Network in 2007

No modifications to the monitoring network were made in 2007 with regards to the frequency of measurements. Based on a recommendation given in 1995, the water-level measurement frequency for the monitoring network wells was reduced from its initial rate to quarterly and has remained so to date. OWSI wells continue to be measured on a monthly basis. Water quality monitoring is conducted on an annual basis.

No new wells were added to the monitoring network in 2007. The Devine Well, one of several domestic supply wells in the monitoring network, was reconfigured in 2003 such that it could no longer be monitored, and it has not been subsequently replaced. In 2005, OWSI completed two new production wells, Wells 15 and 16, both of which were added to the current monitoring network in 2005. Over the past two years Well 16 has been in the process of being placed into service and no new data

has been generated at this site since initial construction. However, Well 13, which is adjacent to Well 16 serves as a redundant monitoring point. Well 15, which is not currently being used for production, provides a good non-pumping observation point for the South Aquifer.

Port Ludlow Area Aquifers

Robinson, Noble, & Saltbush has conducted several studies in the Port Ludlow area evaluating the groundwater resources. In these previous studies, four principal aquifers were identified. These are the North, South, South Valley, and Well 1 Aquifers (Robinson & Noble, 1987). The four aquifers were defined using differing methods dependent on the type and amount of information available. A detailed explanation of the methods used can be found in Appendix E of the Port Ludlow Development Program EIS. The boundaries of the four area aquifers, and the locations of the wells that currently comprise the monitoring network, are shown on Figure 1.

Identification of Monitoring Wells

When the monitoring network was originally set up, Robinson, Noble, & Saltbush developed a preliminary list of acceptable wells to be included. These wells were selected to provide a comprehensive coverage of the area encompassing the aquifers. The preliminary list of wells included several of the OWSI wells and wells belonging to all known water purveyors operating around and within the boundaries of the North and South Aquifers. Also included were privately owned domestic wells located in areas of concern. Because some owners of wells on the preliminary list, including some water purveyors, declined to participate, a few additional private wells were subsequently added to the monitoring network.

Currently, OWSI withdraws water from only the North and South Aquifers. The water company's wells in the North Aquifer are completed from 139 feet above mean sea level (MSL) to 37 feet below MSL. OWSI's wells in the South Aquifer are completed from 12 to 137 feet below MSL. In selecting wells to monitor in the North and South Aquifer areas, the completion elevation of the well, and not simply the location, was a primary consideration.

In addition to monitoring the North and South Aquifers, the monitoring network includes three wells owned by OWSI located in and near the South Valley Aquifer. These wells allow long-term monitoring of the South Valley Aquifer, which currently has no active production wells.

Jefferson County Public Utility District (JCPUD) has an existing monitoring program for wells in the Shine area. Data from that monitoring program have been obtained and included in the Port Ludow monitoring network. Table 1 lists all of the wells included in the current monitoring network.

Discussion of Data Collected

Information gathered for each well is discussed below. For comparison purposes, the water level data for the monitoring network was compiled and plotted on similar scales. Water level data is referenced to

individual measuring points, typically top of casing. The most recent water quality results are provided in Table 2. The historical trends and ranges for chloride and conductivity are discussed for each well. Note that the State drinking water standards for chloride and conductivity are 250 mg/l and 700 micromhos/cm, respectively. Rainfall data are also discussed in a separate section following the individual well discussions.

Olympic Water and Sewer, Inc. Monitoring Wells

Well 2

Well 2 is located in the North Aquifer. The static and pumping water levels and annual production are shown on Figure 2. The water level data show seasonal trends (short term annual pattern) as generally declining in the summer and increasing (recharging) in the winter. Static water levels in Well 2 during 2007 ranged between 94.5 and 102.15 feet below the measuring point (bmp). The long-range water level pattern shows a steady decline from 1972 to 1991, followed by a relatively constant level between 1991 and 1994. Starting in 1994, static water levels show a slightly increasing trend until 1999, a steady trend until the end of 2001, and a declining trend to present.

Table 1. List of wells in the Port Ludlow area monitoring program as of January 2005

Owner	Well name	Location	Aquifer area
Olympic Water and Sewer, Inc.	Well 2 Well 3 Well 4N Well 4A Well 9 Well 12 Well 13 Well 14 Well 15 Well 16	T28N/R1E-8K -8H -8P -21F -21F -29A -21R -21R -21R -21R	North " South Valley " South " " " " " " " " " " "
Neault	Private	-15R	South
Woodruff (Hayden- Elaser)	Private	-8L	North
Jefferson County WD#1	Paradise Bay	-276	South
Jefferson County PUD	Bywater #1 Bywater #2 Shine Plat #2	-34M -35D -33N	South " "
Hendrickson	Private	-34L	South
Hill	Private	-33Q	South

Between 1972 and 1994, static water levels and pumping water levels are generally parallel to one another. However, after 1994 and continuing up through the present, static and pumping water levels show an increasing divergence or separation from one another. This is often indicative of decreasing well efficiency. A loss of efficiency was verified with pumping tests conducted in 2004 and again recently in January 2008. In 2004, attempts were made to rehabilitate Well 2, obstructions present in because of several rehabilitation was not possible. In 2004, following testing and rehabilitation efforts, Well 2 was equipped with a new pump, which has the intake set at a lower level to compensate for the efficiency losses in the well. The new pump has a higher instantaneous production

rate than the previous pump. The average production from Well 2 in 2004 was 34.7 gpm, which was up from the two previous years. In 2006 and 2007 the average annual production from Well 2 increased to 47.7 and 50 gpm respectively. At the higher pumping rates, pumping levels in Well 2 (as shown on Figure 2) are notably lower than the levels prior to the pump being replaced. With the new pump installed, static and pumping water levels appear to be diverging more than from before it was installed. This divergence was again linked (through recent testing) to an increasing loss of well efficiency. OWSI is currently making plans to construct a second well at the Well 2 site to augment production losses from both Well 2 and Well 3 (as discussed below).

Water quality results from Well 2 show that the chloride and conductivity have been variable throughout the history of the well, with an overall slightly increasing conductivity trend and relatively stable chloride trend. Although conductivity concentrations appear to be increasing slightly, they are still well below the drinking water limit, and in the absence of an increasing chloride trend, it is not indicative of seawater intrusion. Records dating back to 1968 show the chloride concentration in this well has ranged from 3.7 to 11 mg/l and conductivity has ranged from 108 to 206 µhoms/cm. No new water quality data were recorded for 2007.

Well 3

Well 3 is located in the North Aquifer. The static and pumping water levels and annual production are shown on Figure 3. Like Well 2, the water level data show the short-term seasonal trends as generally declining in the summer and recharging in the winter. Static water levels in Well 3 during 2007 ranged between 189.0 and 197.2 feet bmp. The long-range water level pattern, particularly after 1980, indicate that there is a fairly strong responsiveness between water levels and production. Between 1980 and 1983, water levels rose, apparently in response to a reduction in production. Between 1983 and 1987, both production and water levels remained fairly stable. After 1987 and up through 1992, water levels fluctuate in apparent response to increases and decreases in annual production. After 1992, up through 2001, production and water levels again remain fairly constant; Starting in 1998, water levels actually begin to rise (with production constant), likely a reflection of increasing precipitation which is associated recharge.

After 2001 and up through the present, water levels at Well 3 decline markedly in apparent response to progressive increases in production (between 1992 and 2001, annual production ranged from 11.5 gpm to 14.7 gpm; in 2002, 2003, and again in 2004, production increased to 18.9, 23.3, and 27.2 gpm respectively). Production was relatively stable during 2005 and 2006 but water levels continued to decline. In 2007, OWSI reduced production from 26.5 gpm during the previous year to 20.8 gpm in an attempt to stabilize the declining water level trend. As shown on Figure 3, this appears to have been somewhat effective. However, pumping levels in Well 3 are currently near the pump intake and screen levels in the well. Additional production decreases will likely be required to provide some reserve drawdown (to compensate for

seasonal fluctuation) and to increase the water level over the pump (to provide for more efficient pumping operation).

Water quality results from Well 3 show that the chloride and conductivity have been fairly stable throughout the history of the well, with records dating back to 1986. Chloride concentrations have ranged from 2.0 to 9.9 mg/l, and conductivity has ranged from 155 to 227 µhoms/cm. No new water quality data were recorded for 2007.

Well 4N

Well 4N is also located in the North Aquifer. Figure 4 shows the water level and production information for Well 4N. The short-term water level pattern for Well 4N exhibits a larger seasonal variation than in either Well 2 or Well 3. In 2007, the static water level ranged from 178.2 to 213.0 feet bmp. Similarly to Well 2, the long-term water level pattern for Well 4N show a slightly increasing trend from 1994 until 1999, then a steady trend until the end of 2001. After 2001 through present, water levels have been declining, in apparent response to continually increasing production. The average annual production rate at Well 4N steadily increased from 31.2 gpm in 2002 to 47.9 gpm in 2007. As at Well 3, pumping levels in Well 4N are near the pump intake and screen top in the well. Production at this site may, over the next year, need to be reduced to preserve a sufficient drawdown reserve (to accommodate seasonal variation) and sufficient water over the pump inlet (to allow for proper pump operation).

Water quality results from Well 4N show that the chloride and conductivity have been stable throughout the history of the well, with records dating back to 1980. The chloride concentration has consistently been less than 5 mg/l, and the conductivity has ranged from 149 to 204 μ homs/cm. No new water quality data were recorded for 2007.

Well 4A

Well 4A is an inactive well located in the South Valley Aquifer. A hydrograph for the well is presented on Figure 5. In 2007, water levels measured in Well 4A were at or above the top of casing. This is consistent with the highest historical levels observed. Water quality results for this well show the chloride concentration has ranged from 5.0 to 6.5 mg/l, and the conductivity has ranged from 165 to 310 µhoms/cm. No new water quality data were recorded for 2007.

Well 9

Well 9 is another inactive well located in the South Valley Aquifer. Its hydrograph is presented on Figure 6. In 2007, water levels in Well 9 ranged from 6.6 to 7.8 feet. This is comparable to the range in previous years, which show a stable trend since monitoring of the well began in 1994. Water quality results show the chloride concentration has ranged from 4.8 to 9.0 mg/l, and the conductivity has ranged from 150 to 245 micromhos/cm. No new water quality data were recorded for 2007.

Well 12

Well 12 is also an inactive well located in the South Valley Aquifer. A hydrograph for Well 12 is presented on Figure 7. In 2007 the static water levels ranged from 5.2 to 6.2 feet. These levels are consistent with historical levels for this well. Water quality results show that the chloride concentration has ranged from 3.0 to 5.0 mg/l, and the conductivity has ranged from 77 to 120 μ homs/cm. No new water quality data were recorded for 2007.

Well 13

Well 13 is located in the South Aquifer. Figure 8 presents the water level and production data for the well. Figure 8 shows that the static water level in Well 13 remained relatively constant until 1994. In 1994, the static water level appears to decline (or step-down) approximately three feet. This decline is likely due to a data error resulting from the change from airline readings to manual soundings in September 1994. At that time, a new pump was also installed in the well that provided a higher instantaneous production rate. As such, the pumping water level declined at this time as well. Following installation of the new pump, the static water level declined approximately two feet between 1994 and 1995. Since late 1995 through present, the static water level has remained relatively stable with the exception of a slight decline of approximately one foot occurring over the past four to five years. This apparent decline, which occurs over a period of relatively steady to decreasing production, is likely the result of lower than average precipitation that has occurred over the past several years.

The pumping water levels in Well 13 were relatively steady between 1995 through 1999, but, because of diminishing well efficiency, began to decline through mid 2004. Efforts to rehabilitate Well 13 were not successful and, consequently, production capacity has been curtailed in this well since 2004. This is evident in that the average production in 2007 was 35.3 gpm, which is down from 41.3 gpm in 2006. Two new production wells (Wells 15 and 16) were constructed in 2004/2005 to replace lost production from Well 13. At the time of this report, neither Well 15 nor 16 had been placed into permanent service. The seasonal fluctuation in Well 13 is fairly minimal as compared to OWSI wells completed in the North Aquifer. In 2007 the static water level in Well 13 ranged from 366.9 to 369.0 feet.

Water quality results from Well 13 show that throughout the history of the well the chloride has been fairly steady and conductivity has been slightly increasing. Although conductivity concentrations appear to be increasing slightly, they are still well below the drinking water limit, and in the absence of an increasing chloride trend, are not indicative of seawater intrusion. Records dating back to 1983 show the chloride concentration has ranged from 3.9 to 5.9 mg/l, and conductivity has ranged from 138 to 206 μ homs/cm. No new water quality data were recorded for 2007.

Well 14

Well 14 is also located in the South Aquifer. Figure 9 presents the water level and production data for the well. Like Well 13, Figure 9 shows that there is minimal seasonal fluctuation in Well 14, as compared with the OWSI wells completed in the North Aquifer. In 2007 the static water level in Well 14 ranged from 374.4 to 378.0 feet bmp. The long-term water level pattern shows that the static water level gradually declined approximately one foot between the time the well was put on line in 1993 through 1998, but was stable thereafter through at least 2002. The current 2007 data indicate static water levels have declined approximately two feet over the past several years. As with Well 13, this decline is likely in response in part to lower than average precipitation that has occurred over this period. However some component of the decline is also likely in response to higher production demand, which has been steadily increasing over the past ten years. The pumping water level in this well has been steadily declining since 1997, which appears to correspond with the increase in production over the same period. Annual average production in 2007 was, however, only 68.6 gpm, which is down from 84.3 gpm in 2006.

Water quality results from Well 14, which date back to 1993, show that both the chloride concentration and conductivity have remained relatively stable. Chloride values have ranged between 0.3 and 7.9 mg/l. Conductivity has ranged from 141 to 200 μ homs/cm.

Well 15

Well 15 is also located in the South Aquifer approximately 1,000 feet north of Well 14. Well 15 was constructed in early 2005 to replace declining production at Well 13. However, because of water quality issues related to arsenic and hydrogen sulfide odor, OWSI does not have immediate plans to put this well into production. Figure 10 presents an initial hydrograph of Well 15. At time of construction in February 2005, the static water level in Well 15 was 405.6 feet bmp. Subsequent measurements in August 2005 indicate a seasonal fluctuation of approximately two feet, which is comparable to the fluctuation observed in Wells 13 and 14. Static water levels measured in Well 15 during 2007 ranged between 406.5 and 407.9 feet. The well is currently not used for production so no production data is presented.

Water quality results obtained during the initial testing of Well 15 show that the chloride concentration was 4 mg/l in 2005, and the conductivity was 184 μ homs/cm. No new water quality data were recorded for 2007.

Well 16

Well 16 is located in the South Aquifer approximately 100 feet southeast of Well 13. Like Well 15, Well 16 was constructed in the summer of 2005 to replace declining production at Well 13. OWSI is currently working to put Well 16 into permanent service. Figure 11 presents an initial hydrograph of Well 16. At time of construction in July 2005, the static water level in Well 16 was 376.0 feet bmp. Subsequent measurements of this well have not been made so seasonal fluctuation has not been assessed. Considering the proximity of Well

16 to Well 13, however, it is expected that the seasonal fluctuation in these two wells will be comparable. Since Well 16 is not currently in service, no production data is presented.

Water quality results obtained during the initial testing of Well 16 in 2005 show that the chloride concentration was 4 mg/l and the conductivity was 169 μ homs/cm. No new water quality data were recorded for 2007.

Private Wells

Woodruff (Hayden-Elaser) Well

The Woodruff well, now owned by Michael and Nancy Hayden-Elaser (but continued to be referred to herein as the Woodruff well), is the only private well in the monitoring network completed in the North Aquifer. A hydrograph of this well is presented as Figure 12. The Woodruff well was reported to have been deepened at some point after initial construction to 219 feet. No water level information is available for the time of original construction. The water level measured at the initiation of monitoring (May 17, 1993) was 151.2 feet bmp. Subsequent water level measurements generally show a decline in summer months and rise in winter months. The variation may be in part a response to seasonal variation, as well as a response to seasonal pumping of wells in the immediate vicinity. The long-term water level pattern shows a general rise between 1994 and 1999 of approximately 10 feet. After that point water levels appear to be relatively stable until 2002 and then declining through the present. In 2007, water levels ranged between 155.8 and 164.05 feet, compared to the 2002 level range of 146.4 and 148.4 feet. The recent declining trend is likely related to the declining trend observed in the other North Aquifer wells. Water quality analyses show that chloride concentrations have ranged from 2.5 to 5.9 mg/l. Conductivity has ranged from 152 to 221 µhoms/cm.

Devine Well

The Devine well is located on the northern fringe of the South Aquifer, near the shoreline of Port Ludlow Bay, in Ludlow Beach Tracts. In 2003 the wellhead for this well was reconfigured such that there is no longer access to measure water levels. The static water level measurements for this well through 2003 are shown on Figure 13. The original static water level at construction (May 14, 1980) was reported to be 39 feet. The initial water level measurement for the monitoring network (May 17, 1994) was 38.5 feet. With the exception of two water level measurements made in August 1994 (likely post-pumping recovery levels), the data show a slight rising trend (less than two feet) through 1999. The data collected after 1999 show a slight water level decline through 2000 and a leveling off through 2003. Water levels recorded through 2003 are consistent with the original static level and do not indicate an overall declining trend. Based solely on its proximity to the shoreline, this well is likely affected by tidal fluctuations to some degree. Seasonal fluctuation appears to fairly minimal. In 2003, water levels in the well ranged between 37.5 and 38.9 feet. Water quality analyses show that the chloride concentration

has ranged from 3.0 to 7.5 mg/l, and the conductivity ranged from 223 to 320 µhoms/cm. No new water quality data were recorded for 2007.

Neault Well

The Neault well is located on the fringe of the South Aquifer, near the shoreline of Puget Sound, at Tala Shores. The water levels measured in this well are presented in Figure 14. According to the State Water Well Report for this well, the original static water level at construction (January 25, 1978) was 15 feet below the top of casing. The initial monitoring network water level (June 1, 1993) was 31.5 feet. Subsequent water level measurements have been highly This variability is likely caused by a complicated variable. combination of factors including tidal influences, seasonal variation, and pumping activity. A number of off-trend (extremely low) water level measurements taken initially in 1994 and 1995, and then again in 2002 and 2003 are almost certainly post-pumping recovering water levels and don't represent true static levels. Other recent off-trend measurements recorded in 2006 and 2007, (particularly the 39 foot recorded for January 15, 2007 and the 53.5 measurement measurement recorded for July 11, 2007) also likely represent postpumping recovering water levels and not true static levels. general long-term water level pattern for this well (estimating between the variations and excluding obvious off-trend measurements) appears to be steady between 2000 and 2005, and possibly decreasing up through the present. Water quality analyses show that the chloride concentration has ranged from 3.9 to 10 mg/l. Conductivity has ranged from 185 to 250 Uhoms/cm.

Hendrickson Well

The Hendrickson well, which replaced the Hodges well in the monitoring network in 1995, is a private domestic well located in the southern portion of the South Aquifer northeast of the Shine area. The water levels measured for this well are presented on Figure 15. The original static water level at construction (September 25, 1980) was reported to be 161 feet. In conjunction with the testing of JCPUD's Bywater Well 1, the Hendrickson well was monitored continuously from March 2 through 7, 1992. During that time period, the water levels varied between 159.8 to 160.2 feet, much of which appeared to be in response to barometric changes. The initial network water level (August 2, 1995) was 158.5 feet. In 2007, water levels ranged between 161.46 and 163.7 feet. Historically, water levels in this well have been relatively stable through 2000 and then declining through present. Water quality analyses show that the chloride concentration has ranged from < 5.0 to 11.8 mg/l, and the conductivity has ranged from 139 to 206 µhoms/cm. These low and high values were recorded respectfully in 2003 and 2007, and when viewed with the intermediate values, there appears to be slightly increasing conductivity trend. However, when compared with the entire 14 year record, this trend is much less pronounced, and together with the stable conductivity trend, does not seem to currently indicate that there is a saltwater intrusion problem.

Jefferson County Water District #1's Paradise Bay Well

The Paradise Bay Well is located in the central portion of the South Aguifer. Static water levels, and limited pumping water levels have been provided from 1994 through 2004 (Figure 16). Water level data (static or pumping levels) have not been provided since 2004. Production data has been provided from 1994 through 2005 but no new data was provided for 2006 or 2007. The Water District reported that the static water levels in 2004 ranged between 321 and 322 feet, which was down slightly from the previous two years but within historical trends. Production records show a slight, but progressive, increase in production between 1997 and 2004. In 2005 the average continuous production rate was reported as 14.1 gpm, down slightly from 15.7 gpm during the previous year. Water quality analyses have been conducted quarterly since 1995. These analyses show the chloride concentration has ranged from 1.9 to 5.9 mg/l, and the conductivity has been between 116 and 178 Uhoms/cm.

Jefferson County PUD's Monitoring Network Wells

Bywater Bay Well 1

Bywater Bay Well 1 is located in the South Aquifer area approximately 1% miles south of OWSI's Wells 13 and 14. This well is included in JCPUD's monitoring network and, for a time, was also monitored by Pope Resources. In 1997, Pope Resources deferred monitoring to JCPUD. The water level and production data collected for this well are shown on Figure 17. The initial network water level (May 22, 1992) was 163.6 feet bmp. Relatively stable water levels were measured thereafter until 1999. Between 1999 through 2002, the water level trend is declining. After 2002 through present, the water level trend in this well appears to be relatively stable. However, some of the water levels (particularly after 1999) appear to represent pumping or postpumping recovering water levels and may not accurately reflect water level trends. The anomalously low water level measured on July 1, 2002 (206.7 feet) almost certainly represents a pumping water level and has been plotted as such. Water levels measured during the second half of 2006, along with the water level measured on July 9, 2007 (191.9 feet), also appear to represent levels intermediate between static and pumping levels. Static water level variation in 2006 and 2007 were anomalously high and likely does not reflect true seasonal variation.

Water quality analyses show that the chloride concentration in this well has ranged from 2.9 to 7.7 mg/l, and the conductivity has ranged from 162 to 250 μ homs/cm.

Bywater Bay Well 2

Bywater Bay Well 2 is located in the southeast portion of the South Aquifer approximately 1% miles southeast of OWSI's Wells 13 and 14. Like Bywater Bay Well 1, Bywater Bay Well 2 is currently monitored by JCPUD. Water level and production data collected for the monitoring network are presented in Figure 18. This well was reportedly deepened from 254 feet to 323 feet in 1994. The static water level, at the time the well was deepened, was 252.2 feet. The initial monitoring water level (May 23, 1994) was 258.0 feet bmp. In 2007, water levels in this

well ranged between 259.15 and 291.8 feet. The static water level data for this well reported between 1996 and present indicate an overall declining trend. However, water levels appear to be relatively stable for approximately the past three years. Production data for this well is relatively sparse, and it is difficult to accurately decipher a trend.

Water quality analyses for Bywater Bay Well 2 show that the chloride concentration has ranged from 5.0 to 19 mg/l, and the conductivity has ranged from 110 to 326 μ homs/cm. The overall water quality pattern shows a slightly increasing trend for chloride and a relatively stable trend for conductivity since 1994. The trend is somewhat irregular though and does not definitively indicate saltwater intrusion. Both the chloride concentrations and the conductivity are currently well below regulatory limits.

Shine Plat Well 2

The Shine Plat Well 2 is a community well located in the Shine area, outside the identified boundary of the South Aquifer. Measured water levels collected for the network are presented in Figure 19. The original static water level at construction in 1991 was reported to be at a depth of 2 feet. The initial monitoring water level (September 1993) was 14.8 feet. Subsequent water level measurements have been highly variable. In 2007, measured water levels ranged from 5.0 to 32.8 feet. This variability is likely caused by pumping activity in both this well and the nearby Shine Plat Well 1. Overall, however, a generally stable trend is represented by the highest recorded water levels since 1995. Water quality analyses show that the chloride concentration has ranged from 4.2 to 10 mg/l, and the conductivity has ranged from 183 to 255 µhoms/cm.

Hill Well

The Hill well is a private domestic well located on the southern fringe of the South Aquifer along the shoreline of Puget Sound in the Shine area. A hydrograph representing water levels collected for the network is presented as Figure 20. The original static water level at construction in 1983 was reported to be 30 feet. A water level of 36.5 feet was measured by Roats Engineering in September 1993. Subsequent measurements have showed considerable variation. This variability is likely a result of a combination of factors including pumping activity at the Hill well itself, seasonal variation, and possibly tides. In 2007, water levels ranged from 32.6 to 49.2 feet. Generally, the long-term water level pattern appears to indicate a declining trend between 1995 and 2001, and then a relatively stable trend through present.

Water quality analyses show that the chloride concentration in this well has ranged from 24 to 35 mg/l, and the conductivity has ranged from 339 to 475 μ homs/cm. Both the chloride and conductivity levels are relatively high compared to other wells in the network, suggesting minor saltwater influence, but not necessarily saltwater intrusion. The Hill well is located approximately 500 feet from the shoreline, and its static water level is, at times, approximately 10 feet above sea level with pumping water levels occasionally below sea level. The

well location, water levels, and the completion elevation of 20 to 25 feet below sea level make the Hill well susceptible to saltwater intrusion. To date, however, water quality data collected for the monitoring network show stable to slightly declining chloride and conductivity levels, and no clear indication of an increased risk of saltwater intrusion.

Water Quality

The results from the most recent water quality analyses for the monitoring network are given in Table 2. For historical values, please refer to previous year-end summary reports. Historical water quality data show stable chloride concentrations and conductivity values for all the wells except for the Hendrickson Well, which shows possibly a very slightly increasing trend for conductivity. Further monitoring is needed to substantiate this apparent increase. The most recent water quality data show chloride concentrations and conductivity values are within the State drinking water standards for all wells in the network.

Rainfall

Precipitation in the Port Ludlow area has been collected at the OWSI office since 1979. Plots of annual totals at Port Ludlow and at NOAA's Chimacum 4S weather station are given on Figure 21. The 29-year average for Port Ludlow is 32.83 inches per year (in/yr). This compares to the 28-year average at the Chimacum Station (2007 records not yet available for Chimacum) of 29.03 in/yr. The difference of 3.80 in/yr between the two locations is consistent with the isohyetal map in Water Supply Bulletin 54. However, the averages are greater at Port Ludlow and Chimacum than that suggested by the isohyetal map (which is based on 1931-1960 data).

Since 1991, rainfall has also been collected at a "South Bay" station located at Well 13. Rainfall in 2007 totaled 28.82 inches at the Port Ludlow office and 33.72 inches at the South Bay station. The 17-year average for the South Bay station is 34.42 in/yr, slightly above the Port Ludlow office station average for the same period.

Summary

Fourteen years of monitoring have provided for an analysis of the condition of aquifers in the Port Ludlow area. The monitoring network, initiated in April 1994, currently includes 18 wells from seven participants, including four wells in the Shine area that are part of a Jefferson County PUD monitoring network.

In general, all wells in the network show seasonal variations. Water levels decline in the spring/summer months and rise in the fall/winter months. These variations are likely contributable to a combination of several factors. Most of the natural recharge to the aquifers occurs in the fall/winter, causing a rise in water levels. Then, increases in withdrawals from area aquifers during the spring through fall accentuate the normal decline in water levels occurring as a result of the natural discharge of the aquifers during the time of lower recharge. Other non-seasonal factors, such as barometric effects (some

wells have been shown to be nearly 100% efficient in the area), tidal effects, and measurements of post-pumping recovering water levels, add to the "noise" of the trend analyses. With the seasonal variations in mind, none of the aquifers within the monitoring network, with the exception of North Aquifer, showed a significant overall decline from historical levels in 2007. OWSI combined annual average production for 2007 was 222.6 gpm (359.1 acre feet) from all aquifers, up by 5.9 gpm (9.5 acre feet) from 2006. This increase in production, combined with lower than average precipitation that has persisted since 2000, appears to be resulting in declining trends in the various area aquifers, and especially within the North Aquifer.

In the North Aquifer, Wells 2, 3, and 4N show a general rise of water levels between 1993 and 2001. A programmed decrease in withdrawal rates from the aquifer was initiated in 1993. Water levels in Wells 2 and 3, and the private Woodruff Well, also completed in the North Aquifer, rose approximately five feet during that time. This rise was likely a direct result of the decreased withdrawal. However, over the past several years, water levels in Wells 2, 4N, and the Woodruff Well have declined more than this amount and in Well 3 nearly twice this amount. This recent decline is likely due to lower than average precipitation that has persisted in recent years and increased production from the aquifer (specifically at Wells 2, 3, and 4N) that has occurred during this same period. In the seven year period between 2001 and 2007, total withdrawal from the North Aquifer by OWSI increased incrementally from 71.7 gpm (116 acre-feet/year) to 118.7 gpm (191.5 acre-feet/year).

In the central portion of the South Aquifer, production at OWSI's Wells 13 and 14 has generally been steadily increasing since 1996. Production at Well 13 has decreased overall since 2003 because of problems with the well, but production at Well 14 has increased incrementally (to compensate for lost production at Well 13) over this same period. Production at the JCWD #1 Paradise Bay Well has remained generally constant between 1996 and 2005 (no new data were received in 2006 or 2007). The static water level in each of these three wells appears to have declined slightly over that past six to seven years, likely in response to both an overall increase in production and lower than average precipitation that has persisted since 2000. In the seven year period between 2001 and 2007, total withdrawal from the South Aquifer by OWSI increased overall from 98.5 gpm (158.9 acre-feet/year) to 103.9 gpm (167.6 acre-feet/year). For the southern portion of the South Aquifer, data for both the Bywater Bay Well 1 and Bywater Bay Well 2 also show a possible decline in water levels since 1999. However, the inclusion of pumping and recovering water levels with the static water level data set may be presenting an erroneous trend.

Table 2. Most recent water quality analyses of wells in the Port Ludlow area monitoring network

Well Name	Chloride (mg/l)	Conductivity (µhoms/cm)	Date sampled
Well 2	5.6	203	1/10/06

Well 3	5.5	197	1/10/06
Well 4N	<5.0	186	1/10/06
Well 4A	5	310	9/7/95
Well 9	4.9	245	2/20/96
Well 12	5	120	8/29/88 & 11/30/72
Well 13	<5.0	196	1/10/06
Well 14	<5.0	166	10/17/07
Well 15	5	184	2/5/05
Well 16	4	169	8/4/05
Devine Well	<5.0	223	10/8/03
Woodruff Well	<5.0	180	10/17/07
Neault Well	5.71	220	10/17/07
Hendrickson Well	<5.0	206	10/17/07
JCWD#1 Paradise Bay Well	<5.0	142	10/23/07
JCPUD Bywater Well 1	<5.0	189	10/17/07
JCPUD Bywater Well 2	10.8	293	10/17/07
Shine Plat Well 2	<5.0	214	10/17/07
Hill Well	26.1	381	10/11/07

With the exception of the Devine well, the private wells in the network located within 500 feet of the shoreline show highly variable water levels, the largest being up to 50 feet in Shine Plat Well 2. The variation in water levels is most likely the result of the combination of tides, barometric effects, seasonal recharge, and variations in pumping activity in the monitored wells and/or wells in their immediate vicinity. Even with these variations, the overall trends observed in the private wells appear to be steady, or slowly declining since 1999. The apparent decline in water levels is likely related to below average precipitation over the past several years prior to 2007.

In the South Valley Aquifer, water levels in Wells 4A, 9, and 12 show stable water levels with seasonal variations of up to four feet. These variations are most likely the result of variations in seasonal recharge. No additional data were recorded for these wells in 2007.

Water quality results from the monitoring network wells show that chemistry has remained relatively stable in all aquifers. The

Hendrickson well is the only well that shows conductivity above normal background levels. This well shows a slightly elevated conductivity level that, although well below the drinking water standard of 700 µhoms/cm may be indicative of possible incipient saltwater intrusion. However, based on the full fourteen year conductivity record, there is not currently a clear indication of a trend toward increasing conductivity levels in the Hendrickson well. The highest conductivity level to date was set in 2007, but several more years of monitoring would be needed to determine if this is a single anomalous year or an upward trend.

Recommendations

The Port Ludlow groundwater monitoring program continues to function as designed. The current program provides adequate coverage and information on the aquifers in the Port Ludlow area. The continuation of monitoring water levels and water quality sampling in all network wells will allow long-term trend analysis of the aquifers in the Port Ludlow area. Based on the information gathered in 2007, the frequency of water level measurements can be maintained at quarterly intervals. Water quality sampling should remain on an annual basis, including the Hill well. It is also recommended that the monitoring of rainfall continue at the Olympic Water & Sewer's office and at the South Bay gage.

The monitoring program has collected a strong baseline of data and has provided an initial, long-term trend analysis. With the exception of the North Aquifer, there are currently no definitive indications of significantly declining water levels related to groundwater production or rising chloride and conductivity levels. The hydrographs for wells completed in the North Aquifer indicate that the aquifer water levels This declining trend, which has been currently declining. occurring since 2001, appears to be related to both lower than average precipitation and increasing production from the aquifer. OWSI has recently initiated plans to address this issue, which includes construction of additional wells, exploration for an alternate deeper source in the North Bay area, and possibly shifting production to other aquifer systems (namely the South and South Valley Aquifers). In the interim, continued caution and additional vigilance is warranted for the next several years with regards to this system in particular. The continuation of the monitoring program can insure that proper management of the groundwater resource is maintained.

The statements, conclusions, and recommendations provided in this report are to be exclusively used within the context of this document. They are based upon generally accepted hydrogeologic practices and are the result of analysis by Robinson, Noble, & Saltbush, Inc. staff. This report, and any attachments to it, are for the exclusive use of Port Ludlow Associates, LLC. Unless specifically stated in the document, no warranty, expressed or implied, is made.